19. A method according to claim 9, wherein the ratio of the thickness of the top substrate layer to the thickness of the additional substrate layer is greater than one.

20. A method according to claim 12, wherein the ratio of the thickness of the top substrate layer to the thickness of the additional substrate layer is greater than one.

REMARKS

The office action of January 7, 2000 has been reviewed and its contents carefully noted. Reconsideration of this case, as amended, is requested. Claims 1 through 12 remain in this case, claims 13 through 17 being cancelled, claim 12 being amended, and claims 18-20 being added by this response. Support for claims 18-20 is found in the specification at p. 10, lines 14-18. No new matter has been added.

The Restriction Requirement

The Examiner has made a restriction requirement and has identified two groups as follows:

Group I – claims 1-13, drawn to a method

Group II – claims 14-17, drawn to a product

During a phone interview, the Applicant's attorney told the Examiner that Group I, claims 1-13 would be elected for further prosecution without traverse. Applicants hereby affirm the election of Group I. Applicants reserve the right to pursue the nonelected claims in a divisional application.

The Rejection under 35 U.S.C. § 112

Claims 12 and 13 were rejected under 35 U.S.C. 112, second paragraph, as being incomplete for omitting essential steps, such omission amounting to a gap between the steps. Specifically, the Examiner stated that claim 12 had no physical steps. Claim 12 has been amended to include the steps recited in claim 13 and claim 13 has been cancelled. Reconsideration and withdrawal of the rejection is respectfully requested.

The Rejection under 35 U.S.C. § 102

Claims 1, 7, and 8 were rejected under 35 U.S.C. 102(b) as being anticipated by Shimbo *et al.* (US 4,738,935). The rejection is respectfully traversed.

In order to avoid rejection for anticipation, it is only necessary to show that a claim contains at least one element not disclosed in a single prior art reference. The invention is directed to a method for forming low defect density epitaxial layers on lattice-mismatched substrates. The method of claim 1 includes choosing a first epilayer and a top substrate layer for epitaxial growth, determining a first lattice constant and a first thermal expansion coefficient of the first epilayer, determining a second lattice constant and a second thermal expansion coefficient of the top substrate layer, bonding an additional substrate layer to the top substrate layer to form a composite substrate so that the first epilayer has either positive lattice mismatch and negative or zero thermal mismatch to the composite substrate, or negative lattice mismatch and positive or zero thermal mismatch to the composite substrate, and choosing a buffer layer which is lattice matched to the first epilayer to be deposited on the composite substrate before depositing the first epilayer. The buffer layer has positive thermal mismatch to the composite substrate when the buffer layer and the top substrate layer have positive lattice mismatch, and the buffer layer has negative thermal mismatch to the composite substrate when the buffer layer and the top substrate layer have negative lattice mismatch. None of these steps are found in the Shimbo et al reference. Instead, this reference is directed at bonding two substrates together with a simple method.

The rejection asserts that the mental steps would be performed inherently while lattice engineering III-V semiconductor compounds. The Office Action, however, provides no basis for this assertion, and the present application in fact provides examples of prior art approaches, in the specification at pp. 2-3, that show otherwise.

In one such prior art method, a strain-graded buffered layer gradually transforms the lattice constant from the value of the substrate to the final desired value of the epitaxial layer. In another approach, strained superlattices are employed to bend threading dislocations. These methods can be used jointly with mesa growth, and while effective in decreasing threading dislocations, there remain sufficient threading dislocations which severely degrade device

performance and reliability. There are also other limitations with these methods that are described further in the present specification. Accordingly, significant deficiencies remain with prior art methods.

In particular, with lattice mismatched layers, when employing thermal stress to provide a long range stress field, the sign of stress is reversed when the material temperature varies from higher to lower than the epitaxial growth temperature at which the thermal stress is zero. This means that although the thermal stress can confine dislocations at high temperatures, the stress from the source can unleash the confined dislocations at low temperatures. It is recognized in the art pertaining to the invention that the problem of thermal stress reversal, e.g. from compression to tension, offsets the benefit of etch pit density ("EPD") reduction that thermal cycling provides to the material. Upon cooling to room temperature, data demonstrates that the density of threading dislocations as indicated by EPD returns to reach the surface of the film (Tachikawa, M. and Mori, H., "Dislocation Generation of GaAs on Si in the Cooling Stage", Appl. Phys. Lett. 56 (22): 2225-2227 (1990), attached). One proposed solution to this problem, employing multi-layer substrates that can dynamically adjust the stress over different temperature ranges, can increase the substrate cost and process complexity.

The present invention provides a less costly and simpler solution. The constrained defects are not unleashed and threaded up to the surface upon cooling. The steps of the invention the Examiner refers to as "mental steps" are not proposed or suggested in Shimbo, nor are these performed inherently in prior art procedures as asserted in the Office Action. This is clearly evidenced by the fact that the prior art does not disclose solving these problems when employing lattice mismatched layers.

Therefore, it is respectfully proposed that the rejection of claim 1 for anticipation by the Shimbo *et al.* reference is overcome. Reconsideration and withdrawal of the rejection is respectfully requested.

Dependent claims 7 and 8, being dependent upon and further limiting independent claim 1, should also be allowable for that reason, as well as for the additional recitations they contain. Applicants respectfully request reconsideration and withdrawal of the rejection of claims 7 and 8 under 35 U.S.C. §102 (b), in view of the above amendments and remarks.

The Rejections under 35 U.S.C. § 103

Claims 2-4 and 12 were rejected under 35 U.S.C. 103(a) as being unpatentable over Shimbo *et al.* as applied to claims 1 and 7-8, and further in view of Lee *et al.* (US 4,900,372). The rejection is respectfully traversed.

In determining obviousness, the basic issue is whether applied references, alone or in any combination, suggest the claimed invention as a solution to the specific problem solved. When the prior art itself does not suggest or render obvious the claimed solution to that problem, the art involved does not satisfy the criteria of 35 USC § 103 for precluding patentability. Obviousness cannot be established by combining the teachings of the prior art to produce the claimed invention, absent some teaching, suggestion, or incentive supporting the combination. *Carela v. Starlight Archery*, 231 USPQ 644 (Fed. Cir. 1986).

The above arguments are reiterated in full as applied to this rejection. As with the primary reference, the secondary reference, Lee, does not disclose or suggest the present method. In particular, Lee does not teach determining the lattice constant and thermal expansion coefficient of the final epilayer and the top substrate layer, bonding an additional substrate layer under the top substrate layer to form a composite substrate so that the desired epilayer has negative or zero thermal mismatch to the composite substrate if the lattice mismatch between the epilayer and the top substrate layer is positive or has a positive or zero thermal mismatch if having a negative lattice mismatch, and choosing a buffer layer to be deposited before the desired epilayer which is lattice matched to the epilayer; or, that the chosen buffer layer should have a positive thermal mismatch to the entire substrate if the lattice mismatch is also positive or a negative thermal mismatch if the lattice mismatch is negative.

Dependent claims 2-4 being dependent upon and further limiting independent claim 1, should also be allowable for that reason, as well as for the additional recitations they contain. Applicants respectfully request reconsideration and withdrawal of the rejection of claims 2-4 under 35 U.S.C. §103 (a), in view of the above amendments and remarks.

As amended, claim 12 contains the additional steps of thermally annealing the buffer layer and substrate when the buffer layer reaches a thickness of a bending radius of at least a

majority of threading dislocations present in the buffer layer, and repeating the growing and annealing steps until an aggregate buffer layer thickness is above the bending radius of all threading dislocations present in the buffer layer. These very specific steps are neither taught nor suggested in either the Shimbo *et al.* nor the Lee *et al.* references. Therefore, reconsideration and withdrawal of the rejection is respectfully requested.

Claims 5-6, 9-11,12 were rejected under 35 U.S.C. 103(a) as being unpatentable over Shimbo *et al.* and Lee *et al.* as applied to claims 1, 7-8 above, and further in view of Lee *et al.* (US 4,900,372). The rejection is respectfully traversed. The above arguments are reiterated in full with respect to this rejection.

As amended, claim 12 contains the additional steps of thermally annealing the buffer layer and substrate when the buffer layer reaches a thickness of a bending radius of at least a majority of threading dislocations present in the buffer layer, and repeating the growing and annealing steps until an aggregate buffer layer thickness is above the bending radius of all threading dislocations present in the buffer layer. These very specific steps are neither taught nor suggested in either the Shimbo *et al.* nor the Lee *et al.* references. Therefore, reconsideration and withdrawal of the rejection is respectfully requested.

Dependent claims 5-6, and 9-11 being dependent upon and further limiting independent claim 1, should also be allowable for that reason, as well as for the additional recitations they contain. Applicants respectfully request reconsideration and withdrawal of the rejection of claims 5-6, and 9-11 under 35 U.S.C. §103 (a), in view of the above amendments and remarks.

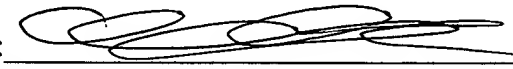
Conclusion

Applicant believes the claims, as amended, are patentable over the prior art, and that this case is now in condition for allowance of all claims therein. Such action is thus respectfully requested. If the Examiner disagrees, or believes for any other reason that direct contact with Applicants' attorney would advance the prosecution of the case to finality, he is invited to telephone the undersigned at the number given below.

"Recognizing that Internet communications are not secured, I hereby authorize the PTO to communicate with me concerning any subject matter of this application

by electronic mail. I understand that a copy of these communications will be made of record in the application file."

Respectfully Submitted:
Lo *et al.*

By: 
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